# Effect of problem-based, self-directed undergraduate education on life-long learning

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**Objective:** To compare how well graduates of a self-directed, problem-based undergraduate curriculum (at McMaster University [MU], Hamilton, Ont.) and those of a traditional curriculum (at the University of Toronto [UT]) who go on to primary care careers keep up to date with current clinical practice guidelines.
**Design:** Analytic survey. Management of hypertension was chosen as an appropriate topic to assess guideline adherence. An updated version of a previously validated questionnaire was mailed to the participants for self-completion.
**Setting:** Private primary care practices in southern Ontario.
**Participants:** A random sample of 48 MU graduates and 48 UT graduates, stratified for year of graduation (1974 to 1985) and sex, who were in family or general practice in Ontario; 87% of the eligible subjects in each group responded.
**Main outcome measures:** Overall and component-specific scores; analysis was blind to study group.
**Results:** The overall mean scores were 56 (68%) of a possible 82 for the MU graduates and 51 (62%) for the UT graduates (difference between the means 5, 95% confidence interval 1.9 to 8.2; $p < 0.01$). Multivariate linear regression analysis of seven factors that might affect questionnaire scores revealed that only the medical school was statistically significant ($p < 0.01$). The MU graduates had significantly higher mean scores than the UT graduates for two components of the questionnaire: knowledge of recommended blood pressures for treatment ($p < 0.05$) and successful approaches to enhance compliance ($p < 0.005$). The trends were similar for the other components but were not significant.
**Conclusions:** The graduates of a problem-based, self-directed undergraduate curriculum are more up to date in knowledge of the management of hypertension than graduates of a traditional curriculum.

**Objectif :** Comparer dans quelle mesure les diplômés d'un programme d'études de 1er cycle autonome et axé sur les problèmes (à l'Université McMaster [UM], Hamilton [Ont.]) et les diplômés d'un programme d'études traditionnel (à l'Université de Toronto [UT]) qui poursuivent des carrières en soins primaires se tiennent au courant des lignes directrices actuelles en matière de pratique clinique.
**Conception :** Enquête analytique. Le traitement de l'hypertension a été choisi comme sujet approprié pour évaluer le respect des lignes directrices. Une version à jour d'un questionnaire précédemment validé a été envoyée par la poste aux participants, qui l'ont rempli eux-mêmes.

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**Cadre :** Bureaux privés de soins primaires du sud de l'Ontario.
**Participants :** Un échantillon aléatoire composé de 48 diplômés de l'UM et de 48 diplômés de l'UT, stratifié en fonction de l'année d'obtention du diplôme (1974 à 1985) et du sexe. Les sujets pratiquaient la médecine familiale ou l'omnipratique en Ontario; 87 % d'entre eux ont répondu dans chaque groupe.
**Principales mesures des résultats :** Résultats globaux et spécifiques par rapport aux composantes; l'analyse était à l'insu du groupe étudié.
**Résultats :** Les résultats pour la moyenne globale étaient de 56 (68 %) sur une possibilité de 82 pour les diplômés de l'UM et de 51 (62 %) pour les diplômés de l'UT (différence entre les moyennes, 5; intervalle de confiance de 95 %, 1,9 à 8,2; $p < 0,01$). L'analyse de régression linéaire à variables multiples de sept facteurs qui pourraient influer sur les résultats du questionnaire a révélé que seule la faculté de médecine était statistiquement significative ($p < 0,01$). Les diplômés de l'UM ont obtenu des résultats moyens significativement plus élevés que les diplômés de l'UT pour deux composantes du questionnaire : la connaissance des tensions artérielles recommandées pour le traitement ($p < 0,05$) et les démarches favorables pour en améliorer le respect ($p < 0,005$). Les tendances étaient semblables pour les autres composantes, mais elles n'étaient pas significatives.
**Conclusions :** Les diplômés d'un programme d'études de 1er cycle autonome et axé sur les problèmes possèdent des connaissances plus récentes sur le traitement de l'hypertension que les diplômés d'un programme d'études traditionnel.

With the rapid evolution of health care knowledge medical practitioners must often upgrade the clinical practices they learned during residency training in order to provide optimum health care. However, physicians are often unaware of new practices and procedures and frequently fail to incorporate advances in medical knowledge into their practices.[1-3] In a 1984 report from the American Association of Medical Colleges' Panel on the General Professional Education of the Physician and College Preparation for Medicine[4] the panel blamed traditional medical education programs for this problem and recommended sweeping changes in undergraduate medical education to promote life-long learning. The main changes included a switch from passive, didactic teaching to active, problem-based, self-directed learning. The undergraduate medical curriculum at McMaster University (MU), Hamilton, Ont., has followed these principles since its inception in 1969. The implications of the approach are very important. If problem-based, self-directed learning does enable life-long learning, a major problem with dissemination of new medical knowledge will have been overcome. If it does not, the many schools struggling to convert their curriculums are doing so in vain.

A recent study reported that medical undergraduates following a problem-based curriculum at Rush Medical College, Chicago, did better on a standardized oral examination than their cohorts who followed a traditional program;[5] the results of the National Board examinations did not differ significantly between the two groups. There has been no convincing evidence that problem-based, self-directed undergraduate learning results in better renewal of clinical practice knowledge than traditional undergraduate programs. One of the main reasons for this lack of evidence is insufficient numbers of graduates of the former type of program for appropriate studies.

To compare the two programs we asked the following question: Do graduates of the problem-based, self-directed learning medical program at MU who go on to primary care careers keep up to date with recommendations for the care of hypertensive patients any differently than graduates of the traditional medical program at the University of Toronto (UT)?

## Methods

Graduates of UT were chosen as the comparison group because of the university's proximity, high academic admission standards and traditional curriculum. Hypertension was chosen as the representative disorder because it is the commonest chronic medical problem seen by primary care physicians,[6,7] a previous survey had shown that time since graduation was strongly negatively correlated with knowledge of its management[8-10] and new guidelines had been published by the Canadian Hypertension Society after the years of graduation of the study subjects.[11-16]

The utility of questionnaires in assessing knowledge of the management of hypertension has been established in various studies.[8,9] We used a self-administered questionnaire that had been previously validated and had demonstrated a negative gradient with time since graduation in three different communities in two different studies, the correlation being $-0.55$ ($p < 0.001$) in one study[10] and $-0.63$ ($p < 0.001$) in the control group in the second.[8] The

questionnaire also showed responsiveness to an educational intervention in a randomized controlled trial, with a significant increase in scores and eradication of the negative gradient between time since graduation and questionnaire scores.[10] The original questionnaire was updated according to evidence-based guidelines published by the Canadian Hypertension Society.[11-16] All but one of the reports had been published after the last group of participants graduated, and several of the earliest recommendations had been superseded by the more recent publications.[12-16]

The questionnaire posed 52 multiple-choice questions, the highest score being 82. The questionnaire examined five areas of practice appropriate for the primary care management of hypertension: methods of measuring blood pressure (total score 15 points), recommended blood pressures for treatment (10 points), pharmacologic treatments (26 points), nonpharmacologic treatments (5 points) and patient follow-up (26 points), including the frequency of return appointments, actions taken after the blood pressure returns to normal, and the detection and management of patient noncompliance. In addition, there were 19 items on demographic features of the respondents and their practice settings. (Copies of the questionnaire are available from the corresponding author.)

A survey frame for the study was constructed from the names and addresses of all physicians on the alumni lists of the MU and UT medical schools who had graduated between 1974 and 1985. Ontario addresses were selected and cross-checked for accuracy with the 1990 *Canadian Medical Directory*, a listing of physicians from the College of Family Physicians of Canada and current telephone listings. The questionnaire was sent to a selection of general practitioners and family physicians, stratified by number of years since graduation and sex. In each year of graduation the first physician representing each school was randomly selected. In the same year the next three physicians were systematically chosen: they were the next three consecutive alphabetically ordered surnames to fulfil the quota of two women and two men for that graduation year.

From previous studies[8,10] the mean questionnaire score for physicians was 50% (standard deviation [SD] 13%). The sample size for the study was calculated to be 36 graduates from each school in order to detect an absolute difference in questionnaire scores of 10%, assuming a score SD of 13%, a two-tailed type I error of 0.05 and a power of 0.9. To allow for a nonresponse rate of 20% and an ineligibility rate of 5% we attempted to recruit 48 physicians from each school. Physicians were ineligible if they were not currently practising primary care medicine or not seeing adult patients with hypertension. Ineligible physicians were removed from analysis and the reasons for removal recorded.

Physicians were encouraged to respond to the questionnaire through letters from the deans of medicine at the two universities. The purpose of the study was stated as an asssessment of the knowledge of physicians of current guidelines for managing hypertension and a comparison of graduates of the two schools. Although the questionnaire's title listed both universities, the questionnaire was clearly identified as coming from MU and was to be returned to that university. The project was approved by the institutional review board at MU, and return of the questionnaire constituted consent. Up to three written reminders and three telephone reminders were delivered. Physicians who did not acknowledge the questionnaire or reminders were visited at their office by one of us (J.H.S.) in an attempt to solicit participation. Those who still did not respond were identified as nonresponders.

After the return of each questionnaire, identifying demographic and personal information of the responding physician, including school of graduation, was separated from the questions about hypertension management for confidentiality and blinding of the analysis of responses.

Before the responses could be analysed a "best answer" and any reasonable option were selected for each question according to recently published guidelines.[11-16] Respondents were credited with a correct answer if they indicated the best answer or a reasonable option. A total score was derived for each participant by summing the correct responses without weighting of the individual responses.

For statistical analysis the main dependent variable was the total survey score and the main independent variable the school of graduation. Secondary analyses were performed for the five areas covered in the questionnaire. Data were entered into a database management program (Paradox, version 3.0, Borland International, Scotts Valley, Calif.), and statistical analyses were performed with the use of SAS for PC (SAS, release 6.04, SAS Institute Inc., Cary, NC). Student's *t*-test was used to compare each area of factual knowledge between the two groups. In secondary analyses the relation of physician characteristics to questionnaire scores was assessed by means of analysis of variance, $\chi^2$ analysis of contingency tables, and univariate and stepwise multiple linear regression analysis. A $p$ value of less than 0.05 was considered statistically significant.

## Results

The questionnaire was mailed to 96 physicians, of whom 84 (88%) responded. Two of the respondents were found to be ineligible because they were

Table 1: Baseline characteristics of primary care physicians who graduated from McMaster University (MU) and the University of Toronto (UT)

| Characteristic | MU (n = 41) | UT (n = 41) |
|---|---|---|
| Mean no. of years of postgraduate training (and standard deviation [SD]) | 2.0 (0.6) | 1.9 (0.6) |
| Certification from the College of Family Physicians of Canada, no. (and %) of physicians | 35 (85) | 34 (83) |
| No. of patients seen per working day, no. (and %) of physicians | | |
| < 20 | 4 (10) | 6 (15) |
| 20–39 | 32 (78) | 31 (76) |
| > 39 | 5 (12) | 4 (10) |
| Proportion of patients with hypertension, no. (and %) of physicians | | |
| < 5 | 4 (10) | 15 (37) |
| 5–14 | 19 (46) | 18 (44) |
| 15–24 | 14 (34) | 8 (20) |
| 25–49 | 4 (10) | 0 |
| Mean no. of hours per week spent in patient care activities (and SD) | 41.0 (10.6) | 37.0 (12.1) |
| Type of practice, no. (and %) of physicians | | (n = 40) |
| Solo | 13 (32) | 6 (15) |
| Two-person | 15 (37) | 12 (30) |
| Group | 13 (32) | 22 (55) |
| Size of community, no. (and %) of physicians | | |
| < 100 000 | 10 (24) | 4 (10) |
| 100 000–500 000 | 17 (41) | 13 (32) |
| > 500 000 | 14 (34) | 24 (59) |
| Distance to nearest medical school, km; no. (and %) of physicians | | |
| < 10 | 17 (41) | 24 (59) |
| 10–20 | 11 (27) | 7 (17) |
| > 20 | 13 (32) | 10 (24) |
| When physicians will usually try a new drug, no. (and %) of physicians | | |
| Before release | 1 (2) | 0 |
| Soon after release | 5 (12) | 3 (7) |
| After a few colleagues have tried it | 13 (32) | 11 (27) |
| When in common use | 19 (46) | 24 (59) |
| When a standard drug | 3 (7) | 3 (7) |
| How often physicians will see pharmaceutical representatives, no. (and %) of physicians | (n = 40) | |
| Almost always | 18 (45) | 7 (17) |
| Occasionally | 18 (45) | 26 (63) |
| Never or almost never | 4 (10) | 8 (20) |
| How often samples from pharmaceutical representatives are important, no. (and %) of physicians | | |
| Often | 11 (27) | 2 (5) |
| Sometimes | 7 (17) | 8 (20) |
| Occasionally | 7 (17) | 10 (24) |
| Never | 16 (39) | 21 (51) |
| Self-rated level of up-to-date knowledge compared with that of colleagues, no. (and %) of physicians | (n = 38) | |
| > 90% | 3 (8) | 4 (10) |
| > 75% | 16 (42) | 7 (17) |
| > 50% | 16 (42) | 25 (61) |
| > 25% | 3 (8) | 3 (7) |
| > 10% | 0 | 2 (5) |
| No. of hours per week in continuing medical education (CME) activities, no. (and %) of physicians | | |
| 1–2 | 17 (41) | 18 (44) |
| 3–5 | 19 (46) | 19 (46) |
| 6–7 | 5 (12) | 4 (10) |
| Eagerness for CME in hypertension, no. (and %) of physicians | | |
| Very interested | 10 (24) | 5 (12) |
| Interested | 25 (61) | 28 (68) |
| Indifferent | 6 (15) | 6 (15) |
| Not interested | 0 | 2 (5) |

not currently treating adults with hypertension. Thus, the response rate among eligible physicians was 87%.

By design the two groups of respondents included almost equal proportions of women and men. The amount of postgraduate training or the number of physicians certified by the College of Family Physicians of Canada did not differ significantly between the two groups (Table 1), nor did most of the other baseline characteristics.

Two of the characteristics, however, did differ between the groups: the proportion of physicians reporting that at least 15% of their patients had hypertension (44% of the MU physicians v. 20% of the UT physicians) ($p < 0.01$) and the proportion of respondents who "almost always" see pharmaceutical representatives (45% v. 17% respectively) ($p < 0.05$). These two factors, however, were found not to be significantly related to the primary outcome measure (total score on the questionnaire) through simple linear regression analysis.

The mean score on the questionnaire was higher for the MU graduates than for the UT graduates (56 [68%] of 82 v. 51 [62%] respectively) (difference between the means 5, 95% confidence interval 1.9 to 8.2; $p < 0.01$). A multivariate linear regression analysis was done with the following variables: number of years in practice, medical school of graduation, certification from the College of Family Physicians of Canada, sex, number of hours per week spent in patient care activities, number of patients seen per working day and proportion of patients with hypertension. The only factor that predicted the total score was the medical school ($p < 0.01$).

The mean scores for all of the components of the questionnaire were higher for the MU graduates than for the UT graduates (Table 2). These differences were statistically significant for two of the five sections: the MU physicians recognized recommended blood pressures for treatment more often than the UT respondents ($p < 0.05$) and were better able to distinguish successful approaches to enhance short-term and long-term compliance ($p < 0.005$). The scores on compliance differed mainly because the MU physicians were more likely than the UT physicians to indicate that the use of less complicated regimens promotes compliance ($p < 0.005$) (Table 3) and that tailoring the patient's regimen to daily habits enhances compliance ($p < 0.05$).

The relation between the test scores and the time since graduation is shown in Fig. 1. The difference between the two slopes was not significant.

## Discussion

We found that the MU physicians were more up to date overall in their clinical knowledge of hypertension management than their UT counterparts. The differences in scores were small but statistically significant. The two groups differed mainly because of the better knowledge of the MU graduates on when to treat hypertension and on useful interventions to assist patients in complying with the treatment, but the MU graduates scored somewhat higher in all areas. The total score for each group was over 60%, higher than the scores of 50%[8] or less[10] in previous studies; this difference may reflect changes in the questionnaire content, the truncated period from graduation in the current study, better continuing learning of graduates of the two schools in our study or other factors.

There are limitations to drawing conclusions from this type of survey. Although it represents the

Table 2: Mean scores for the main components of a questionnaire on the current knowledge of the management of hypertension

| Component | Total possible score | Group; mean score | | 95% CI* for difference |
|---|---|---|---|---|
| | | MU graduates | UT graduates | |
| Detection methods | 15 | 9.9 | 9.5 | −0.38 to 1.18 |
| Recommended blood pressures for treatment | 10 | 9.2 | 8.5 | 0.09 to 1.31† |
| Pharmacologic treatment | 26 | 17.1 | 15.8 | −0.47 to 3.07 |
| Nonpharmacologic treatment | 5 | 3.6 | 3.5 | −0.23 to 0.43 |
| Compliance | 26 | 15.7 | 13.3 | 0.92 to 3.88‡ |
| Overall | 82 | 55.5 | 50.6 | 1.90 to 8.20‡ |

*CI = confidence interval.
†$p < 0.05$.
‡$p < 0.01$.

self-reported practices of primary care physicians in Ontario who graduated from MU and UT, the test scores may not predict actual performance or success in managing hypertension. Other studies, however, have shown that scores on multiple-choice examinations predict performance in clinical practice.[17,18] Nevertheless, we did not attempt to show this for the questionnaire we used, and we do not know whether the small difference we observed in the scores between the two groups has any clinical importance. Also, the questionnaire was self-administered, and thus the MU graduates may have been more motivated than the UT graduates to look up the answers they were unsure of. However, the questionnaire was accompanied by letters of support from the deans of medicine of the two medical schools, and the response rate was the same in the two groups; this suggested that motivation did not differ between the groups.

Another limitation of our study was that we tested current knowledge of only one disorder. Our results may simply reflect differences in emphasis on hypertension in the two schools. Furthermore, it has been shown that a problem-oriented curriculum enhances long-term recall.[19] Better recall of undergraduate learning is, however, an unlikely explanation of our findings, because the questionnaire focused on recommendations produced after the graduation of the participants. In any event, it would be important for future studies to assess the generalizability of the findings to other topics.

Our data do not permit separation of the effect on knowledge of the MU undergraduate curriculum from the influence of its unique admission process.[20,21] Applicants are interviewed and then rated on their personal qualities, communication skills, problem-solving aptitude, and extracurricular and curricular interests and accomplishments. Although acceptable grades in previous university training are required, marks are not emphasized thereafter in the selection process. Indeed, in 1978–79 MU ranked last of the 15 Canadian medical schools reporting preadmission grade-point averages for their first-year students, whereas UT was fourth.[22]

A previous study[23] showed that MU graduates in primary care practice were more likely to be certified

Table 3: Maneouvres used by respondents to encourage patients to comply with antihypertensive medications

| Manoeuvre | Group; % of respondents | |
|---|---|---|
| | MU graduates | UT graduates |
| Use less complicated regimens* | | |
| Sometimes | 7 | 12 |
| Often | 20 | 56 |
| Very often | 73 | 32 |
| Tailor the patient's regimen to daily habits† | | |
| Sometimes | 18 | 27 |
| Often | 45 | 61 |
| Very often | 38 | 12 |
| See the patient more often | | |
| Rarely | 0 | 5 |
| Sometimes | 20 | 27 |
| Often | 48 | 54 |
| Very often | 33 | 15 |
| Establish a contract with the patient | | |
| Never | 8 | 17 |
| Rarely | 30 | 32 |
| Sometimes | 20 | 32 |
| Often | 28 | 17 |
| Very often | 15 | 2 |
| Have the patient monitor blood pressure at home | | |
| Never | 2 | 5 |
| Rarely | 20 | 24 |
| Sometimes | 39 | 46 |
| Often | 27 | 22 |
| Very often | 12 | 2 |

*$p < 0.005$.
†$p < 0.05$.

in family medicine than their contemporaries from the four other Ontario medical schools. However, in our study we did not find any difference between the two groups in the number of physicians certified by the College of Family Physicians of Canada. This may have been because our study was restricted to graduates from two Ontario medical schools practising in Ontario, our sample was smaller or the proportion of women in our study was higher. The finding that the MU graduates were more likely than the UT graduates to indicate seeing pharmaceutical representatives is intriguing but was not related to the differences in scores.

Previous studies have shown a highly significant negative correlation between test scores and the number of years since graduation.[3,8,10] We found a negative correlation for the UT graduates only, but this was not statistically significant. This may have been due to low power to detect a significant correlation because we had a small sample or because we included physicians who graduated within a relatively narrow band of time (1974 to 1985). Previous studies[8,10] involved physicians who had graduated from a variety of medical schools and included a much wider time span since graduation. From one of those studies[8] we assessed the test scores of physicians who had been practising for the same number of years since graduation as those in our study and within the same time span. We found no significant difference between our observations and those of the previous study. The slope of the scores in the previous study (−0.60) was not significantly different from zero and was clearly due to the small number of participants within the truncated window of time since graduation. A recent study involving internists reported a statistically significant inverse correlation of −0.30.[3]

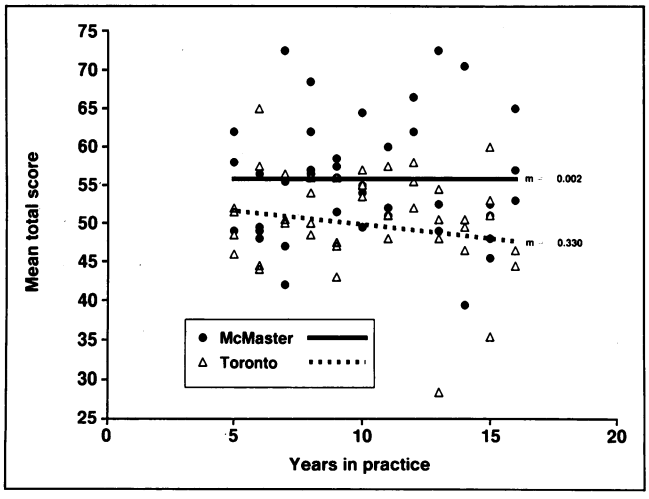


**Fig. 1: Relation of mean total scores of questionnaire on current clinical management of hypertension and time since graduation among graduates of self-directed, problem-based undergraduate curriculum (at McMaster University, Hamilton, Ont.) and those of traditional curriculum (at University of Toronto); m = slope of regression lines.**

Given these limitations, the difference in current knowledge of hypertension between the MU and UT graduates was most likely due to differences in the approach to undergraduate education. This finding is supported by those from a previous study,[24] which showed that MU graduates feel better prepared than fellow postgraduate trainees in independent learning, self-evaluation and problem-solving skills. Graduates emphasized that they had acquired the tools to continue their own education in medicine through the strengths of the integrated, problem-based, active approach to learning. That this may be the key to continued learning after graduation is supported by an investigation by Day and collaborators.[25] On voluntary recertification examinations older physicians did as well as more recent graduates on "stable" information (i.e., information that had not changed since the time of graduation) but did not perform as well on questions about information judged independently as "changing" or "new."

Problem-based learning differs from problem solving in that the patient problems are used as a springboard for learning; the solution of the problem, although worth while, is not an end in itself. Consideration and analysis of a specific problem is intended to heighten awareness of the general picture and its variations, which may result in modification of the proposed solutions. In the MU curriculum students learn through inquiry to set clear learning objectives from the study of health care problems and from early contact with patients. Students must identify areas of deficiency in their own performance, find appropriate educational resources, critically appraise these resources, evaluate personal learning progress and apply newly acquired knowledge and skills in solving patient problems. This curriculum is purposely flexible to maximize opportunities for students to take responsibility for their own learning, the ultimate goal being to combat progressive obsolescence of physicians' skills with the passage of time. This approach to medical education appears to meet the recommendation of the American Association of Medical Colleges.[4]

To keep abreast of new scientific information and new technology, physicians continually need to acquire new knowledge and learn new skills. Therefore, a general professional education should prepare medical students to learn throughout their professional lives rather than simply to master current information and techniques. Active, independent, self-directed learning requires among other qualities the ability to identify, formulate, and solve problems; to grasp and use basic concepts and principles; and to gather and assess data rigorously and critically.

A priority for future studies will be to determine whether patient management differs as a result.

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